44th Leeds-Lyon Symposium on Tribology - September 4-6, 2017, Lyon, France

EXTENDED LUBRICATION THEORY FOR COMPRESSIBLE FLOW

Sean Piela and John Tichy*
*tichyj@rpi.edu
[a] Rensselaer Polytechnic Institute
Troy NY USA 12180

KEYWORDS
lubrication; compressible; fluid mechanics

ABSTRACT

The present study extends the scope of compressible lubrication theory by considering a more complete formulation of compressible flow in a thin film. The classical compressible Reynolds equation is derived by first assuming incompressible conditions in the momentum equation. As a final step, density is substituted from the ideal gas equation to account for the compressibility. The present analysis starts with compressible conditions from the beginning. By averaging across the film, we obtain an approximation in terms of average flow velocity, which is common in basic studies of compressible flow. We examine a dimensionless formulation of the thin film compressible flow equations (continuity, x- and y-momentum, energy, and perfect gas). There are three dimensionless governing parameters: the Mach number the compressibility or bearing number, and a heat transfer number (a sort of inverse Peclet number). The classical theory assumes isothermal conditions (a consequence a large heat transfer number) and implicitly assumes low Mach number conditions. It turns out that neither of these conditions is met in many high speed applications such as foil bearings. We examine the influence of Mach number and heat transfer. The improved theory predicts much greater load than the traditional. This means that high speed air bearing design based on compressible lubrication theory would function satisfactorily, as borne out by their successful application; however, such bearings would be significantly over-designed. The present paper is an extension of previous studies by considering 2D bearing analysis.

REFERENCES

[1] Dupuy F, Bou-Saïd B, Garcia M, Grau G, Rocchi J, Crespo M, Tichy J, “Tribological study of a slider bearing in the supersonic regime,” *ASME Journal of Tribology*, 2016 **138**

[2] Dupuy F, Bou-Saïd B, Tichy J, “High Speed Compressible Lubrication,” *ASME Journal of Tribology*, 2014. **136**